MAGNETIC FIELD DISTRIBUTIONS IN A PLASMA SHIELD LAYER DURING HIGH-POWER PLASMA STREAM-TARGET INTERACTION

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The distributions of magnetic field in front of the target were measured by the local movable magnetic probe with the maximum diameter of 6 mm. The magnetic probe was located at the distance of 2.3 m from the accelerator QSPA Kh-50 output [2].

For measurements of the magnetic field distributions at the different distances from the target surface a special system for target displacement along the axis of the vacuum chamber was utilized. This system consists of a cog-wheel, a rack and a supporting bar. It was placed inside the output conical vacuum chamber of the QSPA Kh-50 device. The minimum distance between the accelerator output and the target position was 2.25 m and the maximum one - 2.7 m (the maximum spacing of measurements was 45 cm). The scheme of experiments is presented in the Fig.1.

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Fig.1. The scheme of experiment

The MPG -7 graphite targets with diameter of 5, 13 and 22 cm were used.
3. The magnetic field distributions at the vicinity of a target

The radial distributions of the magnetic field were measured for the different distances from the target surface and for the different moments of time. The measured radial distributions of the magnetic field in plasma shield, normalized by the value of a vacuum magnetic field, are shown in Figs. 2, 3, 4 and 5 for the moment of time of (170-180) µs. This moment corresponds to the maximum power density in the plasma streams, generated by the QSPA device [2].

One can see the presence of a local minimum of the magnetic field in the plasma at the radius R = 8 cm for the target with a diameter of 5 cm and at the radius (13-14) cm for the target with a diameter of 13 cm (Fig. 2 and 3). This local minimum was caused by plasma flowing around the target. The coordinate of this local minimum of the magnetic field (local minimum outside the target) moves outward the axis with increasing the target diameter.

The value of the magnetic field minimum was decreased with increasing the target diameter. The local minimum in the radial distributions of the magnetic field near the target with diameter 22 cm was not found (Fig. 4).

Thus, the maximum radius of the plasma shield (radius of the plasma shield is the point where \( B_{\text{plasma}} = B_{\text{z0}} \)) was decreased with increasing the target diameter from 12-13 cm (for the target diameter of 5 cm) down to (7-8) cm (for the diameter of 22 cm).
It follows from this picture that the magnetic field in the plasma shield is increased with increasing the distance from the target. The minimum value of magnetic field was found in front of the target at the distance $L = (1+3)$ cm from its surface. The magnetic field in this region of the shielding plasma layer is increased with increasing the target diameter from $0.25xB_{02} = 0.135$ T (for the target diameter of 5 cm) up to $0.85xB_{02} = 0.46$ T (for the diameter of 22 cm). The effect of the target presence was seen in the distributions of the magnetic field in the shielding layer measured up to the distances of 20 cm from the surface of the sample (Fig. 6).

The magnetic measurements carried out inside and behind the graphite target had shown that the magnetic field force lines are frozen into the target. The value of the magnetic field inside and behind of the target with the diameter of 13 cm was up to $0.95xB_{02}$ (Fig. 7).

The estimations of the plasma temperature were performed for the distance from the sample where the minimum magnetic field in the plasma shield exists. The results of the plasma temperature estimation (with using pressure balance equation) for the targets of the different diameters are shown in the table.

**Table. The parameters of the shielding plasma**

<table>
<thead>
<tr>
<th>Diameter of the target, cm</th>
<th>5</th>
<th>13</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from the target, cm</td>
<td>1</td>
<td>2-3</td>
<td>2-4</td>
</tr>
<tr>
<td>Magnetic field, kG</td>
<td>1.35</td>
<td>3.24</td>
<td>4.6</td>
</tr>
<tr>
<td>Pressure in the shielding plasma layer, $x10^{17}$, eV/cm³</td>
<td>4.8</td>
<td>1.9</td>
<td>2.2</td>
</tr>
<tr>
<td>Plasma density, $x10^{16}$, cm⁻³</td>
<td>17</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>$T_{plasma} = (T_e + T_i)$, eV</td>
<td>16-17</td>
<td>11-12</td>
<td>7</td>
</tr>
</tbody>
</table>

On the base of these determinations of the electron temperature the degree of the plasma shield magnetization was estimated. The local plasma temperature $(T_e + T_i)$ in the near-axis region, estimated from the pressure balance equation, was about (15-20) eV for the target with the diameter of 5 cm. It was decreased up to 6-7 eV with increasing the target diameter up to 22 cm.

It is well known that the plasma is magnetized and can’t be moved across the magnetic field lines for the parameter $\omega_0 \tau_e >> 1$. In our experiments the Hall parameter $\omega_0 \tau_e$ was about 0.4-0.5 for all targets. In this case the plasma shield can propagate across the magnetic field lines.

Thus, the obtained experimental results showed that the distributions of the magnetic field in the plasma shield are strongly dependent on both the target diameter and the distance from its surface. The plasma flowing around the target is the reason for the local minimum magnetic field presence in the plasma shield.

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**References**

